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Analysis of Kiwifruit Orchard Financial Performance, Including Covariates

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1 Introduction

The ARGOS project has collected financial data from panels of kiwifruit orchards over several years. The Economics team of the project has conducted analysis of the data to investigate differences amongst the orchards arising from their management systems. The results suggested that organic and conventional orchards had differences in some revenue and expense categories, but these differences netted out when the financial aggregates were calculated. As a result, bottom-line numbers like Effective Orchard Surplus were statistically similar for organic and conventional orchards (Greer et al, 2008 and Saunders et al, 2009).

Following inter-disciplinary discussion of these results and consultation with end-users, the authors undertook the analysis reported here. The focus was on three issues:

1. How robust was the overall finding to different model specifications?
2. What factors were affecting financial aggregates, if management system was not?
3. How confident could stakeholders be in the results, given the design of the project?

The present research built on the earlier work by incorporating a number of factors identified by the ARGOS team that could affect financial performance. These factors were then included in statistical analyses to determine their contribution to financial performance. The analysis thereby produced answers to the three questions above.

This report describes the methods used for the analysis, the results obtained, and the implications of those results for the financial performance of kiwifruit orchards.

2 Methodology

The ARGOS project has been examining the environmental, social and economic sustainability of different faming systems in several of New Zealand's agricultural sectors. One of the sectors investigated is the kiwifruit sector, which is the subject of the present analysis. The programme used a longitudinal panel cluster design – assembling clusters of three orchards using different management systems. In 2003, twelve clusters of three orchards were selected on the basis of geographic proximity; orchard size; willingness of farmers to participate in an intensive long-term study; and growers' involvement with market audit and certification schemes. The three panels of kiwifruit orchards were (1) certified green organic (*Actinidia deliciosa* 'Hayward'); (2) integrated - GlobalGAP certified gold (*Actinidia chinensis* 'Hort16A'); and (3) conventional - GlobalGAP certified green (Hayward).

The audit and certification schemes associated with organics, GlobalGAP, and ZESPRI dictate the farm management practices that kiwifruit orchards may and may not use. The use of different management practices may have financial implications for the orchards. The panel structure of the data allows for statistical comparison of orchard performance, both between green and gold kiwifruit and between organic and conventional management. The orchards within each cluster are close together geographically to minimise differences in background variables such as soil type and climate. Ten clusters are in the Bay of Plenty with one each in Kerikeri and Motueka. These locations are consistent with the industry distribution of orchards and will potentially allow extrapolation to the wider industry.

A discussion of methods for collecting and analysing financial data can be found in Greer, *et al.* (2008). Essentially, participating orchardists made available their financial statements. These were combined with additional information to produce standardised financial records for each orchard in each year. The standardised records were then analysed for differences in individual expense categories, *e.g.*, hired labour, and in financial aggregates, *e.g.*, effective orchard surplus.

In the present research, the analysis has been extended. The approach is explained below.

2.1 Analytical Approach

The key issues for the analysis were the contribution of the management systems to the financial performance of orchards, and the contribution of other factors as well. An ANOVA disaggregates the different sources of variation in a data set, and is used to determine the contribution of several different factors to the overall variation. In additional, correlation analysis determines how the values of two data sets are related to each other, both in direction and magnitude. These two statistical tools were therefore chose as appropriate for investigating the financial performance of the orchards.

The original ARGOS panels were balanced panels of the three management systems. Over time, as is the nature of longitudinal research, some orchards withdrew from the project. In addition, data for some specific years for some orchards were not available. The resulting data set has different numbers of observations for the different management systems and years. An unbalanced ANOVA was used to analyse the data, as this approach accommodates the fact that the number of observations is not the same for each treatment.

The final ANOVA design was as follows:

- The financial variables of interest – the dependent variables – for all analyses were the Gross Orchard Revenue, Cash Orchard Expenditure, Cash Orchard Surplus, and Economic Orchard Surplus. These data were converted to real 2006/7 values (New Zealand dollars) using the Consumer Price Index (all groups).

- The treatment structure applied was the management system (green, gold or organic green kiwifruit).
- The blocking factors used were season (given that data were from several seasons (2002-2006)); and combined orchard (whether an orchard produced both green and gold kiwifruit, or just one cultivar).
- The three covariates were elevation, latitude, and effective area of the orchard (hectares dedicated to growing kiwifruit).

The time since conversion for organic orchards was also considered for inclusion as a covariate data. However, these data were incomplete, so the variable was dropped from the analysis.

Statistical analysis was undertaken using Genstat (Version 11). An example of the ANOVA approach is provided in Figure 1. Where the ANOVA indicated that a variable contributed significantly to the variation of the target financial variable, a correlation between the two was calculated. The correlations indicated whether the variables were positively or negatively related, and how strong the relationship was.

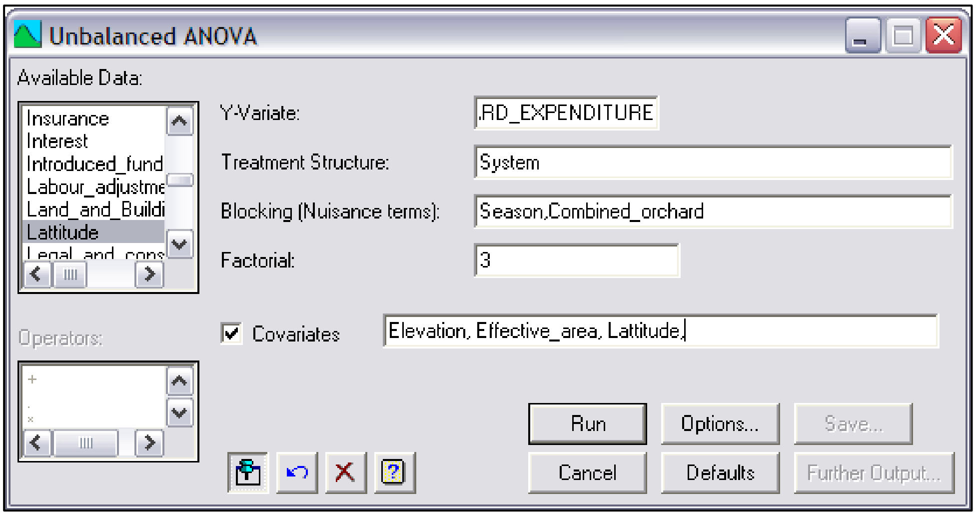

Figure 1. Screenshot of ANOVA Set-Up for Green, Gold and Organic Green Analysis

The analysis was initially conducted using orchard-level data to be comparable with other analyses from the ARGOS project. The analysis was also conducted using per-hectare data to ascertain whether the level at which the analysis was undertaken had any impact on the results. This was particularly interesting for the combined orchards where a much smaller proportion of the orchard was dedicated to a particular cultivar (i.e., green or gold) relative to total orchard size.

Following the initial analysis, the analysis was then conducted with only those orchards that were classified as growing green or organic green kiwifruit. This was undertaken to determine whether there were any differences due to management system for the same cultivar of kiwifruit. Given that the differences in costs and yields can be substantial between green and gold kiwifruit, it was hypothesised that these differences were potentially overshadowing differences between organic and conventional management systems. For this analysis, the blocking factor of combined orchard was removed, as it was no longer relevant. Elevation was not included as a covariate as it was not near significance in the original analysis. Figure 2 provides an example of the analysis set-up.

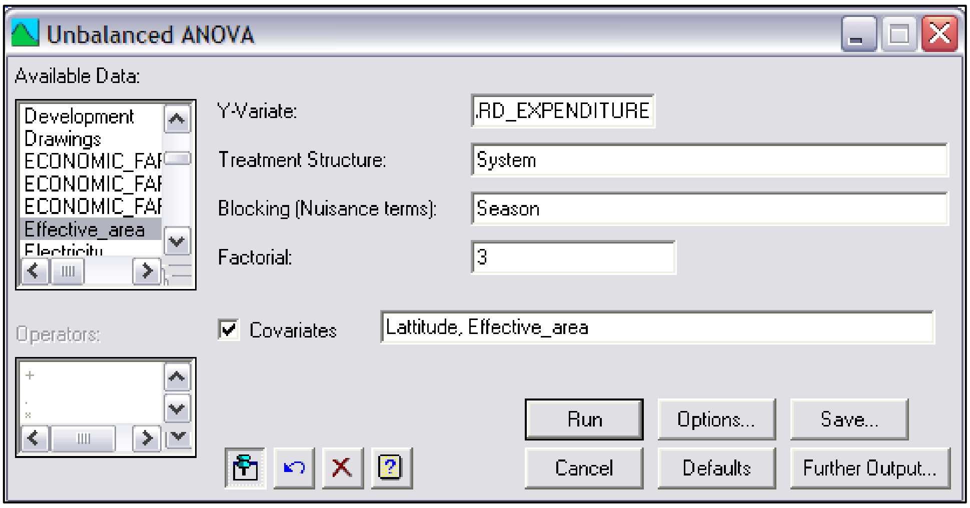

Figure 2. Screenshot of ANOVA Set-Up for Green and Organic Green Analysis

2.2 Data

The financial data for the present analysis were the same as those in previous ARGOS financial analyses (Greer, et al., 2008). The covariate data was provided by J Benge, Field Research Manager for ARGOS, who obtained elevation and latitude data from Google Earth (earth.google.com). The latitude data ranged from 35^{o} to 41^{o} south, while the elevation data ranged from 5 metres to 213 metres above sea level (see Appendix 1 for covariate data).

Data from 31 orchards was used in the analysis. Of these, 10 were green, 11 were organic green and 10 were gold orchards. There was missing data for some years (whole years) for some orchards, as well as some data missing for specific variables for some orchards.

3 Results

3.1 ANOVA per Orchard

Tables 1 through 4 provide the results from the ANOVAs conducted for the four financial elements of interest, using per-orchard data for all three management systems. Initially the analysis assessed statistical significance at the standard level of five per cent. In addition, there was some concern amongst researchers in the ARGOS project that using a five percent significance level increased the possibility that true differences across the management systems were rejected, which is known as a type II error (Geng and Hills, 1989). As a result, it was decided to report results that were statistically significant at the 20 per cent level. At that level, there is a higher probability of type I errors (failure to reject the null hypothesis of no difference between treatments). However, such results are particularly important for suggesting areas of future research, so that studies can be designed around the specific issues of interest.

3.1.1 Gross Orchard Revenue

The Gross Orchard Revenue (GOR) was analysed across the orchards. At the five per cent level of significance, three significant differences were observed: combined orchard (F=0.022), effective area (F<0.001) and system (F<0.001). Those orchards that were not combined, (i.e., produced both green and gold kiwifruit), were significantly more likely to produce a higher gross orchard revenue than those orchards that did produce both cultivars of kiwifruit. Reassuringly, a strong correlation was observed between effective area and gross orchard revenue (r=0.7111). That is, as the effective area increases so does the gross orchard revenue. Inspection of the data suggested that the differences across systems are largely the result of higher GOR for gold orchards.

When the significance level was relaxed to 20 per cent, season became a significant covariate. The 2003/04 season produced a higher gross orchard revenue than the 2005/06 season. This was followed by the 2002/03 season, while the 2004/05 season produced the lowest gross orchard revenue.

Table 1. ANOVA Results for Gross Orchard Revenue, per orchard

Change	Degrees freedom	Sum of squares	Mean sum of squares	Variance ratio	F prob.
+ Season	3	1.797E+10	5.990E+09	1.94	0.128
+ Combined_orchard	1	1.672E+10	1.672E+10	5.41	0.022
+ Elevation	1	2.016E+09	2.016E+09	0.65	0.421
+ Effective_area	1	6.163E+11	6.163E+11	199.60	<0.001
+ Latitude	1	4.667E+09	4.667E+09	1.51	0.222
+System	2	9.032E+10	4.516E+10	14.63	<0.001
Residual	105	3.242E+11	3.088E+09		
Total	114	1.02E+10	9.406E+09		

3.1.2 Cash Orchard Expenditure

When Cash Orchard Expenditure (COE) was analysed, the significant sources of variation were combined orchard (F=0.002), effective area (F<0.001), latitude (F=0.003) and system (F<0.001) at the five per cent level of significance. The correlation between COE and effective area was reasonably strong (r=0.3555), with COE increasing as effective area increases. On the other hand, a negative correlation was observed with latitude (r=-0.2855). That is, as latitude increased, COE decreased. Gold orchards produced a greater COE than both green and organic orchards, and green orchards had a larger COE than organic orchards.

Relaxing the significance level to 20 per cent allowed season to become significant. The 2004/05 season produced the greatest COE, followed by the 2005/06 season. The 2002/03 season produced the lowest COE.

Table 2. ANOVA Results for Cash Orchard Expenditure, per orchard

Change	Degrees freedom	Sum of squares	Mean sum of squares	Variance ratio	F prob.
+ Season	3	6.093E+09	2.031E+09	1.99	0.120
+ Combined_orchard	1	1.019E+10	1.019E+10	10.00	0.002
+ Elevation	1	1.509E+05	1.509E+05	0.00	0.990
+ Effective_area	1	7.805E+10	7.805E+10	76.58	<0.001
+ Latitude	1	9.391E+09	9.391E+09	9.21	0.003
+System	2	5.081E+10	2.541E+10	24.93	<0.001
Residual	104	1.060E+11	1.019E+09		
Total	113	2.605E+11	1.306E+09		

3.1.3 Cash Orchard Surplus

Cash Orchard Surplus (COS) was the third financial aggregate analysed. At the five per cent level of significance, combined orchard (F<0.001), effective area (F<0.001) and latitude (F=0.001) all produced a significant difference. Orchards that produced only green kiwifruit, rather than both green and gold kiwifruit, produced a higher COS. A strong positive relationship was observed between COS and effective area (r=0.6691). Similarly, as latitude increased, COS also increased, although the correlation was not strong (r=0.1846).

At the 20 per cent level of significance, system becomes significant (F=0.108). Gold and organic orchards produced a larger COS than green orchards, but the difference between the COS of gold and organic orchards was relatively small.

Table 3. ANOVA Results for Cash Orchard Surplus, per orchard

Change	Degrees freedom	Sum of squares	Mean sum of squares	Variance ratio	F prob.
+ Season	3	5.773E+09	1.924E+09	0.89	0.449
+ Combined_orchard	1	4.695E+10	4.695E+10	21.72	<0.001
+ Elevation	1	1.337E+09	1.337E+09	0.62	0.433
+ Effective_area	1	1.820E+11	1.820E+11	84.19	<0.001
+ Latitude	1	2.471E+10	2.471E+10	11.43	0.001
+System	2	9.812E+09	4.906E+09	2.27	0.108
Residual	104	2.248E+11	2.162E+09		
Total	113	4.954E+11	4.384E+09		

3.1.4 Economic Orchard Surplus

The final aggregate was Economic Orchard Surplus (EOS), which accounted for both cash and non-cash items. EOS showed similar results to COS, with combined orchard (F<0.001), effective area (F<0.001) and latitude (F=0.005) all showing a significant difference at the five per cent level. Again, being a combined orchard led to lower returns. A strong positive relationship was observed between EOS and effective area (r=0.6082). That is, as the effective area increased so too does the EOS. Similarly, as latitude increased, the EOS increased (r=0.1675).

At the 20 per cent level of significance, system became significant (F=0.113). Gold and organic orchards produced a greater EOS than green orchards, and gold and organic orchards produced similar EOS results.

Table 4. ANOVA Results for Economic Orchard Surplus, per orchard

Change	Degrees freedom	Sum of squares	Mean sum of squares	Variance ratio	F prob.
+ Season	3	3.445E+09	1.148E+09	0.40	0.751
+ Combined_orchard	1	3.8.3E+10	3.803E+10	13.35	<0.001
+ Elevation	1	8.655E+08	8.655E+08	0.30	0.583
+ Effective_area	1	1.698E+11	1.698E+11	59.62	<0.001
+ Latitude	1	2.390E+10	2.390E+10	8.39	0.005
+System	2	1.268E+10	6.338E+09	2.22	0.113
Residual	104	2.963E+11	2.849E+09		
Total	113	5.451E+11	4.824E+09		

3.2 ANOVA per Hectare of Effective Area

For this part of the analysis, the financial data were divided by the number of hectares of effective area in the orchard. Effective area refers to the actual area under cultivation for the cultivar of interest, and thus excluded land area in other crops. Table 5 through Table 8 provide the results from the ANOVAs for the four financial elements of interest, at a per hectare level.

3.2.1 Gross Orchard Revenue

Two significant differences are observed in relation to GOR at the five per cent level of significance. If an orchard is combined, it has a significantly different gross orchard revenue per hectare than if it is a single variety orchard ($F<0.001$). In addition, management system has an impact on gross orchard revenue ($F=0.010$). Gold orchards had a larger gross orchard revenue than both organic and green orchards.

Relaxing the significance level to 20 per cent provided a further two variables that showed a significant difference. Firstly, season became significant ($F=0.146$). The 2003/04 season produced a larger gross orchard revenue than the 2004/05 and 2005/06 seasons, but was similar to the 2002/03 season. Secondly, elevation appears to have an impact on GOR ($F=0.121$).

Table 5. ANOVA Results for Gross Orchard Revenue, per effective hectare

Change	Degrees freedom	Sum of squares	Mean sum of squares	Variance ratio	F prob.
+ Season	3	3.493E+09	1.164E+09	1.83	0.146
+ Combined_orchard	1	9.553E+10	9.553E+10	150.33	<0.001
+ Elevation	1	1.550E+09	1.550E+09	2.44	0.121
+ Effective_area	1	8.128E+07	8.128E+07	0.13	0.721
+ Latitude	1	5.523E+06	5.523E+06	0.01	0.926
+System	2	6.062E+09	3.031E+09	4.77	0.010
Residual	105	6.673E+10	6.355E+08		
Total	114	1.735E+11	1.522E+09		

3.2.2 Cash Orchard Expenditure

At a five per cent level of significance, combined orchard ($F<0.001$), latitude ($F<0.001$) and system ($F=0.042$) all had a significant impact on COE. If an orchard is combined, it is more likely to have a higher COE than if an orchard produces a single cultivar. Gold orchards also produced a larger COE than either green or organic orchards (who have the lowest COE). Latitude also showed a negative relationship with COE; with an increase in latitude, COE decreases ($r=-0.3395$).

Widening the significance level to 20 per cent did not lead to any further significant differences between variables.

Table 6. ANOVA Results for Cash Orchard Expenditure, per effective hectare

Change	Degrees freedom	Sum of squares	Mean sum of squares	Variance ratio	F prob.
+ Season	3	1.116E+09	3.719E+08	0.95	0.418
+ Combined_orchard	1	8.382E+10	8.382E+10	214.85	<0.001
+ Elevation	1	5.062E+08	5.062E+08	1.30	0.257
+ Effective_area	1	2.434E+08	2.434E+08	0.62	0.431
+ Latitude	1	5.545E+09	5.545E+09	14.21	<0.001
+System	2	2.553E+09	1.276E+09	3.27	0.042
Residual	104	4.057E+10	3.901E+08		
Total	113	1.344E+11	1.189E+09		

3.2.3 Cash Orchard Surplus

With respect to COS, at a significance level of five per cent, only one difference was observed. Latitude had a significant impact on COS (F<0.001). Correlation analysis indicated that as latitude increases, COS increases (r=0.3278).

At a significance level of 20 per cent, it was found that season had a significant impact on COS (F=0.103). Inspection shows that the 2003/04 season produced a larger COS than all other seasons.

Table 7. ANOVA Results for Cash Orchard Surplus, per effective hectare

Change	Degrees freedom	Sum of squares	Mean sum of squares	Variance ratio	F prob.
+ Season	3	1.717E+09	5.723E+08	2.11	0.103
+ Combined_orchard	1	1.255E+08	1.255E+08	0.46	0.498
+ Elevation	1	3.180E+08	3.180E+08	1.17	0.281
+ Effective_area	1	1.187E+08	1.187E+08	0.44	0.510
+ Latitude	1	4.967E+09	4.967E+09	18.33	<0.001
+System	2	4.754E+08	2.377E+08	0.88	0.419
Residual	104	2.818E+10	2.710E+08		
Total	113	3.590E+10	3.177E+08		

3.2.4 Economic Orchard Surplus

Regarding EOS per effective hectare, at a five per cent level of significance, three differences were observed: combined orchard (F<0.001), effective area (F<0.001) and latitude (F<0.001). If an orchard only grew one cultivar of kiwifruit, then it had a significantly larger EOS than if two types of kiwifruit were grown. A positive relationship was observed between EOS and effective area (r=0.5066). That suggests that with an increase in effective area, EOS increases, suggestive of economies of scale. A further positive relationship, although not as strong, was observed between EOS and latitude (r=0.3427).

At the significance level of 20 per cent, season became significant. The 2003/04 season produced the largest EOS, followed by the 2002/03 season. The 2004/05 season had the lowest EOS.

Table 8. ANOVA Results for Economic Orchard Surplus, per effective hectare

Change	Degrees freedom	Sum of squares	Mean sum of squares	Variance ratio	F prob.
+ Season	3	1.142E+09	3.806E+08	1.59	0.197
+ Combined_orchard	1	1.284E+10	1.284E+10	53.50	<0.001
+ Elevation	1	2.810E+08	2.810E+08	1.17	0.282
+ Effective_area	1	3.682E+09	3.682E+09	15.34	<0.001
+ Latitude	1	4.396E+09	4.396E+09	18.32	<0.001
+System	2	5.403E+08	2.701E+08	1.13	0.328
Residual	104	2.496E+10	2.400E+08		
Total	113	4.784E+10	4.233E+08		

3.3 ANOVA per Orchard for Green and Organic Green (Hayward Orchards)

Table 9 through Table 12 provide the results from the ANOVAs conducted for the four financial elements of interest, at a per orchard level for green and organic orchards only. This analysis focuses just on the two methods of cultivating the Hayward (green) variety, setting aside the gold kiwifruit orchards.

3.3.1 Gross Orchard Revenue

In analysing GOR for green and organic green orchards, effective area was the only variable that showed a significant difference at the five per cent level of significance (F<0.001). Correlation analysis found that as the effective area increased, so, too, did the GOR (r=0.6457).

At a 20 per cent level of significance, season (F=0.077) became significant. The 2003/04 season produced the largest gross orchard revenue, followed by the 2004/05 season. The 2005/06 had the lowest gross orchard revenue.

Table 9. ANOVA Results for Gross Orchard Revenue, per orchard, Hayward

Change	Degrees freedom	Sum of squares	Mean sum of squares	Variance ratio	F prob.
+ Season	3	1.413E+10	4.411E+09	2.37	0.077
+ Latitude	1	2.334E+09	2.334E+09	1.18	0.282
+ Effective_area	1	4.464E+11	4.464E+11	224.96	<0.001
+System	1	5.234E+08	5.234E+08	0.26	0.609
Residual	71	1.409E+11	1.984E+09		
Total	78	6.096E+11	7.815E+09		

3.3.2 Cash Orchard Expenditure

COE was found to have significant variation across latitude (F=0.003), effective area (F<0.001) and system (F=0.004), at the five per cent significance level. A negative relationship was observed between COE and latitude (r=-0.2169). That is, as latitude increased, the COE decreased. A strong positive relationship was observed between COE and effective area (r=0.7446), so that as COE increased, so did the effective area. Finally, conventional orchards produced a significantly greater COE than organic orchards.

At a 20 per cent level of significance, season became significant (F=0.067). COE has been increasing since this analysis began in the 2002/03 season, with that season producing the lowest COE and the 2005/06 season producing the greatest.

Table 10. ANOVA Results for Cash Orchard Expenditure, per orchard, Hayward

Change	Degrees freedom	Sum of squares	Mean sum of squares	Variance ratio	F prob.
+ Season	3	2.136E+09	7.119E+08	2.50	0.067
+ Latitude	1	2.766E+09	2.766E+09	9.70	0.003
+ Effective_area	1	3.138E+10	3.138E+10	110.00	<0.001
+System	1	2.591E+09	2.591E+09	9.08	0.004
Residual	70	1.997E+10	2.853E+08		
Total	77	5.906E+10	7.670E+08		

3.3.3 Cash Orchard Surplus

For COS, two variables were found to have a difference at the five per cent level of significance: latitude (F=0.048) and effective area (<0.001). Both showed a positive relationship with COS, with latitude (r=0.1637) and effective area (r=0.6457) increasing as COS increased.

At a 20 per cent level of significance, system became significant (F=0.083). Organic orchards produced a significantly greater COS than did green orchards.

Table 11. ANOVA Results for Cash Orchard Surplus, per orchard, Hayward

Change	Degrees freedom	Sum of squares	Mean sum of squares	Variance ratio	F prob.
+ Season	3	1.043E+10	3.478E+10	1.44	0.238
+ Latitude	1	9.756E+09	9.756E+09	4.04	0.048
+ Effective_area	1	1.671E+11	1.671E+11	69.21	<0.001
+System	1	4.458E+09	7.458E+09	3.09	0.083
Residual	70	1.690E+11	2.414E+09		
Total	77	3.657E+11	4.750E+09		

3.3.4 Economic Orchard Surplus

Effective area was the only variable to show a significant difference at the five per cent level for EOS. A strong positive relationship was observed between the two (r=0.5772), with EOS increasing as effective area increased.

At the 20 per cent level of significance, both latitude and system became significant (F=0.163 and 0.098, respectively). Latitude was positively but weakly correlated with EOS (r=0.1273). Organic orchards produced a greater EOS than did green orchards.

Table 12. ANOVA Results for Economic Orchard Surplus, per orchard, Hayward

Change	Degrees freedom	Sum of squares	Mean sum of squares	Variance ratio	F prob.
+ Season	3	9.651E+09	3.217E+09	0.92	0.433
+ Latitude	1	6.899E+09	6.899E+09	1.98	0.163
+ Effective_area	1	1.555E+11	1.555E+11	44.71	<0.001
+System	1	9.767E+098	9.767E+09	2.81	0.098
Residual	70	2.435E+11	3.478E+09		
Total	77	4.263E+11	5.537E+09		

3.4 ANOVA per Hectare for Green and Organic Green (Hayward)

Table 13 to Table 16 provide the results from the ANOVAs conducted for the four financial elements of interest, at a per hectare level for green and organic green orchards only.

3.4.1 Gross Orchard Revenue

At a five per cent level of significance, only latitude showed a significant relationship (F=0.019) with gross orchard revenue. The correlation observed was weak, (r=0.2616), with gross orchard revenue increasing as latitude increased.

At a 20 per cent level of significance, season became significant (F=0.105). The 2003/04 season produced the largest gross orchard revenue, followed by the 2002/03 season. The 2005/06 season produced the lowest gross orchard revenue.

Table 13. ANOVA Results for Gross Orchard Revenue, per hectare, Hayward

Change	Degrees freedom	Sum of squares	Mean sum of squares	Variance ratio	F prob.
+ Season	3	1.061E+09	3.387E+08	2.12	0.105
+ Latitude	1	9.169E+08	9.169E+08	5.74	0.019
+ Effective_area	1	2.886E+07	2.886E+07	0.18	0.672
+System	1	1.010E+06	1.010E+06	0.01	0.937
Residual	72	1.149E+10	1.596E+08		
Total	78	1.346E+10	1.725E+08		

3.4.2 Cash Orchard Expenditure

Three of the four variables showed a significant difference at the five per cent level for COE. The variance associated with effective area was significant (F<0.001), and the correlation was negative and significant (r=-0.3823). The results suggested that as the effective area increased, COE decreased. Latitude also had a negative effect on COE, but this was not as strong as that observed for effective area (F=0.022, r=-0.2329). Finally, there was also significant variance in COE associated with the management system (F=0.051), with conventional orchards having greater COE.

Increasing the significance level to 20 per cent did not allow season to become a significant variable.

Table 14. ANOVA Results for Cash Orchard Expenditure, per hectare, Hayward

Change	Degrees freedom	Sum of squares	Mean sum of squares	Variance ratio	F prob.
+ Season	3	95246982.	31748994.	1.57	0.203
+ Latitude	1	110428042.	110428042.	5.47	0.022
+ Effective_area	1	327246673.	327246673.	16.22	<0.001
+System	1	79620925.	79620925.	3.95	0.051
Residual	71	1432069987.	20170000.		
Total	77	2044612609.	26553411.		

3.4.3 Cash Orchard Surplus

A relationship was observed between COS and effective area and latitude, at the five per cent level of significance (F=0.028 and 0.003 respectively). Both relationships were positive, with COS increasing as the effective area increased (r=0.1796) and as latitude increased (r=0.3196).

At a 20 per cent level of significance, season became significant (F=0.062). The 2003/04 season produced the largest COS, followed by the 2002/03 season. The 2005/06 season produced the smallest COS, as is consistent with other results obtained.

Table 15. ANOVA Results for Cash Orchard Surplus, per hectare, Hayward

Change	Degrees freedom	Sum of squares	Mean sum of squares	Variance ratio	F prob.
+ Season	3	1.346E+09	4.486E+08	2.56	0.062
+ Latitude	1	1.680E+09	1.680E+09	9.57	0.003
+ Effective_area	1	8.796E+08	8.796E+08	5.01	0.028
+System	1	1.295E+08	1.295E+08	0.74	0.393
Residual	71	1.246E+10	1.755E+08		
Total	77	1.650E+10	2.142E+08		

3.4.4 Economic Orchard Surplus

Similar results are seen for EOS as were seen for COS. At the five per cent level of significance, variation in EOS was related to effective area (F<0.001) and latitude (F=0.2597). The positive relationship between effective area and EOS is considerably stronger than that observed for COS (r=0.4255 cf. 0.1796). Conversely, the relationship between latitude and EOS is slightly weaker than the relationship seen for COS (r=0.2597 cf. 0.3196).

Again, relaxing the significance level to 20 per cent allowed season to become significant. The 2003/04 season again produced the largest EOS, followed by the 2002/03 season. As has previously been observed, the 2005/06 season had the lowest EOS.

Table 16. ANOVA Results for Economic Orchard Surplus, per hectare, Hayward

Change	Degrees freedom	Sum of squares	Mean sum of squares	Variance ratio	F prob.
+ Season	3	1.178E+09	3.926E+08	2.47	0.069
+ Latitude	1	1.196E+09	1.196E+09	7.25	0.008
+ Effective_area	1	3.968E+09	3.968E+09	24.93	<0.001
+System	1	1.402E+08	1.402E+08	0.88	0.351
Residual	71	1.130E+10	1.592E+08		
Total	77	1.778E+10	2.310E+08		

3.5 Summary of ANOVAs

Table 17 provides a summary of the ANOVAs reported above. It indicates where the analysis found significant impacts of treatments and covariates on the financial aggregates, the significance level, and the direction of correlations.

Comparing the two levels at which the analysis was conducted, per orchard and per hectare, there were few differences in the contribution of covariates to the observed variance in the financial aggregates. Factors that affected per-orchard results also tended to affect per-hectare results. Latitude generally had a significant impact on all financial variables at the five per cent level of significance, except for gross orchard revenue. Whether the orchard was a combined orchard (i.e., produced both green and gold kiwifruit), was also generally important for financial performance.

One covariate with complex results when examined across the three management systems was effective area. For the financial bottom line, effective area was statistically significant and positively correlated with EOS. However, for GOR and COS, effective area was significant at the orchard level but not for the per-hectare analysis. The relationship between COE and effective area was significant and positive in the per-orchard analysis, but the trend at the per-hectare level was for a negative relationship. Overall, these results suggested rather sensibly that larger orchards have more revenue, expenses, and net earnings, but did not give a strong indication about their per-hectare revenues and expenses compared to smaller orchards.

The analysis on just the conventional and organic green kiwifruit orchards produced results that were fairly similar to the full analysis. Elevation was not considered, and the combined orchards were not included. For season, effective area, and latitude, the results are largely the same as above. Season has a weak impact on the financial aggregates and latitude is significant for per-orchard and per-hectare results. Effective area has a similar complexity across the two orchard types as across the three types. Across the two management systems, there were no differences found in GOR, COS or EOS, although expenses did show a difference at the five per cent level of significance.

Table 17. Summary of ANOVAs

ANOVA and components	Per orchard (Correlation direction)	Per hectare (Correlation direction)	Green orchards, per orchard (Correlation direction)	Green orchards, per hectare (Correlation direction)
Gross Orchard Revenue				
Season	20%	20%	20%	20%
Combined orchard	5%		n/a	n/a
Elevation			n/a	n/a
Effective area	5% (+)		5% (+)	
Latitude		5% (+)		5% (+)
System	5%	5%		
Cash Orchard Expenditure				
Season	20%	5%	20%	
Combined orchard	5%	5%	n/a	n/a
Elevation		20%	n/a	n/a
Effective area	5% (+)	20% (-)	5% (+)	5% (-)
Latitude	5% (-)	5% (-)	5% (-)	5% (-)
System	5%	5%	5%	5%
Cash Orchard Surplus				
Season				20%
Combined orchard	5%	5%	n/a	n/a
Elevation			n/a	n/a
Effective area	5% (+)		5% (+)	5% (+)
Latitude	5% (+)	5% (+)	5% (+)	5% (+)
System	20%		20%	
Economic Orchard Surplus				
Season				20%
Combined orchard	5%	5%	n/a	n/a
Elevation			n/a	n/a
Effective area	5% (+)	5% (+)	5% (+)	5% (+)
Latitude	5% (+)	5% (+)	20% (+)	5% (+)
System	20%	20%	20%	

Overall, the analysis looked at six covariates or factors that were hypothesised to affect the financial performance of kiwifruit orchards. Perhaps the strongest covariate was latitude, which was important for all financial aggregates across all management systems and at both levels of analysis. Effective area was also generally important, as larger orchards had more revenue, expenses, and surpluses. Whether an orchard was combined – grew both green and gold kiwifruit or just the gold variety – was significant. A question that arises is whether the difference was from the actual financial performance or from some experimental error. The elevation of the orchards was not important for this data set. Financial performance did vary by season (year), but this variance was generally not enough to be statistically significant. Finally, some differences were found across the management systems. Overall, they tended to result from differences between the two cultivars, rather than between the two methods for growing green kiwifruit. For the green kiwifruit, most differences observed across the orchards did not remain when the data were analysed on a per-hectare basis.

3.6 Power Analysis

One central question of the research programme was whether organic management systems created different economic, environmental, and social outcomes from conventional systems. Although some specific differences were observed (see above, and Greer et al, 2008 and Saunders et al, 2009), the overall assessment is that conventional and organic farming achieve similar economic farm/orchard surpluses; their bottom-line economic performance is similar. A question that arises is whether these results can be generalised to the whole sector. The question is whether the design of this research was such that the lack of observed significant difference in the sample is indicative of the economic performance of the population of kiwifruit orchards.

One way to explore this question is to conduct a *power analysis* with the data to determine the sample size required to observe a statistically significant result. The ability of an experiment to detect statistical differences is a function of the variability of the sample, the size of the difference, and the sample size (Geng and Hill, 1989). It is possible to determine the statistical power of an experiment, which indicates whether an experiment would be able to detect an effect or difference at a given level of statistical significance (Bausell, 2002). Power analysis may be conducted during the experimental design phase of a study, or afterward to assess a study.

The ARGOS data was subjected to a power analysis, relying on the method in Bausell (2002). Each measure of financial performance, such as GOR, COE, and EOS, could be so analysed. These measures could also be assessed separately for only the green orchards or for all three management systems, and could be assessed on both per-hectare and per-orchard bases. In the end, it was not necessary to conduct the full range of power analyses, as the discussion will make clear.

A power analysis uses a few key numbers. It combines the *effect size* (ES), the number of observations per group (n), and the desired statistical significance (α) to calculate the statistical power of an experiment. The power "ascertain[s] how likely a study's data are to result in statistical significance" (Bausell, 2002, p.1). Larger ES, larger numbers of observations, and lower desired significance all increase an experiment's power. For convenience, tables are used to find the power of an experiment, given values for ES, n, and α.

The method for calculating power and the correct table to use are related to the experimental design. The ARGOS project used a complex experimental design. The design, a panel design with repeated observations and significant covariates, created layers of effects, making it difficult to determine the appropriate method and table. However, this issue did not turn out to be important.

An example of a power analysis is provided. The analysis focused on the power of the project to detect differences in EOS between the organic and conventional green kiwifruit orchards. This focus reduced the experiment to a paired design. The first step in analysing a paired design is to determine the correlation between the paired samples. An analysis of the average EOS over all years for organic and conventional orchards paired by cluster found a correlation coefficient of 0.253. The lowest correlation coefficient considered in the tables in Bausell (2002) was 0.40. As a result, the power analysis reported here relates to experiments with somewhat higher correlations between paired samples. The impact is to overstate the power of the ARGOS design.

The inputs for a power analysis were then calculated:

- ES – The original hypothesis of ARGOS was that there existed no difference in financial performance between organic and conventional orchards. This hypothesis yields an ES of nil. In Bausell (2002), the smallest ES available in the tables is 0.20. The ES is calculated as the difference between the means divided by the pooled standard deviation. Finding the square root of the mean sum of squares of the residual for the analysis reported in Table 16, the standard deviation was estimated to be 12,600. An ES of 0.20 equals a difference between the means of $2,520.
- n – There were a total of 84 observations of EOS by season, 40 of which were conventional and 44 of which were organic. The n was thus set equal to 40 (the maximum number of cases for which there are paired observations).

- *α* – The standard 0.05 probability was used.

The power of the ARGOS experiment, given the discussion above, was 20 per cent (Bausell, 2002, Table 5.1, p. 63). That is, there was an *a priori* 20 per cent probability that the project would be able to detect a $2,520 difference between organic and conventional green orchards at a 0.05 level of statistical significance. To achieve an 80 per cent probability of detecting such a difference, the recommended probability for experimental design (Bausell, 2002), the number of clusters would need to be about 250. Looked at another way, the ARGOS design had an 80 per cent probability of detecting an ES of 0.50, equivalent to a mean difference in EOS per hectare of $6,300.

These power calculations are not exact. They have assumed a paired sample, although the correlation may not be high enough to warrant such an assumption. They have not accounted for the fact that the data are repeated observations of the same orchards, rather than single observations of 84 different orchards. They have not examined the ARGOS null hypothesis of no difference, but instead have calculated the power of alternative hypotheses. Finally, they have used a residual mean sum of squares after accounting for covariates, while the total mean sum of squares was somewhat higher. The net effect of these differences is unknown, as they serve both to under- and overestimate the power of the experiment.

The broad lesson from the power analysis is clear, however, and unaffected by the caveats above. Because of the large variance (or pooled standard deviation) across the sample, the dollar value associated with any given effect size (ES) is large compared to the mean Economic Orchard Surplus (EOS). For example, the mean EOS for the organic orchards was $1,974; for the conventional green orchards, it was -$114 (that is, a loss). These means are smaller than an ES of 0.20, which is equal to $2,520. The *difference* between the two systems would need to be $6,300 – over three times the observed EOS per hectare for organic orchards ($1,974) – in order for the design to detect it with 80 per cent probability.

4 Summary

The present analysis has assessed the contribution of six different covariates or factors to the variance of four key financial aggregates. The intention was to determine whether these covariates or factors were significant for the financial performance of orchards, and in particular whether management system was determinant after accounting for other things.

Although some differences were observed, there were few strong, consistent findings. Management system did show an effect, but not consistently across all financial variables. Mainly, the difference was between the two kiwifruit varieties. Latitude and effective were generally important for financial performance across all orchards and at both levels of analysis. Other factors and covariates generally provided inconsistent results.

The combination of the ANOVA and the power analysis provided an explanation of these findings. There is considerable variability in financial performance across orchards. The variance associated with management system is small compared to this large total variability. As shown here and elsewhere (Greer et al, 2008 and Saunders et al, 2009), the differences between the average financial performance of conventional and organic farms is not large, compared to the variance. The results do suggest that management system is not an important factor in determining orchard financial performance. However, the design of the research programme makes this finding tentative.

5 References

Bausell, R.B. (2002). *Power Analysis for Experimental Research : A Practical Guide for the Biological, Medical and Social Sciences*. West Nyack, NY, USA: Cambridge University Press.

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Greer, G., Kaye-Blake, W., Zellman, E. and Parsonson-Ensor, C. (2008). Comparison of the financial performance of organic and conventional farms. *Journal of Organic Systems 3*(2), 18-28.

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6 Appendices

6.1 Appendix 1 Latitude and Elevation Data

Property ID	Variety Monitored by ARGOS	Elevation (metres above sea level)	Latitude (degrees)
1	Hayward	100	35.1439
2	Hayward	80	35.1439
3	Hort16A	90	35.1453
4	Hayward	10	37.3015
6	Hort16A	10	37.3018
7	Hayward	20	37.3025
9	Hort16A	20	37.3039
10	Hayward	26	37.3941
11	Hayward	20	37.3929
12	Hort16A	20	37.3927
13	Hayward	160	37.4823
14	Hayward	120	37.4816
15	Hort16A	160	37.4818
16	Hayward	140	37.4757
17	Hayward	130	37.4741
18	Hort16A	130	37.4733
19	Hayward	80	37.4818
20	Hayward	110	37.4817
21	Hort16A	110	37.4825
23	Hayward	185	37.5019
24	Hort16A	160	37.5006
25	Hayward	175	37.5056
26	Hayward	175	37.5106
27	Hort16A	213	37.5139
28	Hayward	40	37.4905
29	Hayward	40	37.4859
31	Hayward	20	37.5010
32	Hayward	20	37.4949
35	Hayward	5	41.0720
36	Hort16A	5	41.0648
38	Hayward	20	37.3033